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METHODOLOGY FOR CALCULATING CARRYING AND GRAZING CAPACITY ON PUBLIC RANGELANDS

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Introduction

This document describes the methods used by PLFD Rangeland Agrologists [RA] to calculate carrying and grazing capacities on public **rangelands**[1] in Alberta. It also explains the process for map development and related carrying and grazing capacity procedures in **GLIMPS**.

There are four basic principles of **rangeland management** provide effective rest for **forage** plants between grazing periods; avoid early spring grazing when plants are most vulnerable; distribute animals as evenly as possible across the landscape; and balance livestock requirements with the available forage. When range managers determine the number of head that can be supported by a given site, for a given period of time, they are setting the **stocking rate**. This stocking rate is the balance between the livestock's monthly forage utilization requirements, the plant production and the ecology of the site. **Ecologically sustainable stocking rates** [ESSR] are suggested for each plant community described within Range Plant Community Type Guides.[2] The ESSR reflects the maximum number of livestock [e.g. hectares (ha)/animal unit month (**AUM**)] that can be supported by the plant community given inherent biophysical constraints and the ecological goal of sustainable health and proper functioning of the plant community. When the ESSR is expressed for the area [e.g. ha] of a plant community polygon, the result is termed **carrying capacity** [CC], and is written in AUMs.

Often the CC must be adjusted for **access factors** [e.g. areas that are inaccessible due to natural barriers], and **management factors** [e.g. reduced livestock distribution attributed to livestock management]. This adjusted/reduced carrying capacity is the **grazing capacity** [GC].

Methodology

CCs are determined from data acquired through range surveys, ecological classification, reference sites, grazing and forage growth studies, and long-term monitoring of rangeland health compared to historic stocking rates [Adams et al. 2003]. The methodology for calculating CC on a disposition generally follows four basic steps. These include 1.) Data collection through rangeland inventories and/or health assessment, grazing experience, and follow up monitoring; 2.) Ecological classification of previously unknown plant communities and/or keying to a known community, and determination of ESSR; 3.) Mapping of ecological units; and 4.) Calculation of CC.

1. Rangeland Inventory, Health Assessment, and Monitoring

The management of rangelands depends upon knowledge of animal behaviour, livestock production practices, and the physical and biological characteristics of the land. Unless these are understood prescribing a sustainable level of use, appropriate to a specific area, is difficult.

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[1] Bolded terms are included in glossary.

[2] Web page link to guides: http://www3.gov.ab.ca/srd/land/m_rm_classification.html

Grazing processes on rangelands are dynamic therefore there is no substitute for long-term experience in determining stocking rates on specific rangelands [Holechek et al. 2000]. The dynamic nature of rangelands combined with the limited time frame of many inventories makes it extremely difficult to directly measure CC for herbivores [SRM 2002]. Consequently, SRD has decided to use detailed inventories, rangeland health assessment, monitoring and historic grazing experience to fine-tune ESSR values and the CCs calculated from them.

Generally, detailed inventories are conducted for plant community classification, but like assessments, can also be used to record production and utilization levels. Both forms of data collection can also be used to estimate condition and trends in rangeland health. The methods used by **SRD** for detailed range inventories are outlined in the Range Survey Manual [Dale et al. 2001] and by Robertson and Adams [1990].

Assessments of rangeland health compare the functioning of ecological processes on an area [e.g. plant community polygon] of rangeland to a standard [i.e. **Reference Plant Community**] described within an ecological site description. An **ecological site** is similar to the traditional concept of **range site**, with a broader list of characteristics described. Rangeland health assessments are utilized to make a rapid determination of the ecological status of rangeland. **Range health** terminology [healthy, healthy with problems, or unhealthy] is used to rank the ability of rangeland to perform certain ecological functions. These functions include: net primary production, maintenance of soil/site stability, capture and beneficial release of water, nutrient and energy cycling and plant species functional diversity. For a detailed description on how to assess rangeland health for various plant communities please refer to "Rangeland Health Assessment for Grassland, Forest and Tame Pasture" [Adams et al. 2003].

SRD **RMB** determines ESSR from a combination of inventory and assessments, clipping studies, long-term rangeland reference area data, estimated production, field experience, grazing trials and historical grazing experience. This approach has been used for rangelands where managers must take into account considerable diversity in plant communities and landscape complexity. Rangeland inventories and assessments provide useful contributions to the estimates of present and potential CC of management units, however these and other estimates [e.g. production clips] are often based on a limited time frame and may not reflect long-term variability in plant productivity [SRM, Feb 2002]. Field experience and historical grazing experience are utilized to supplement or to be the basis for the determination of the ESSR when that information exists. The value of establishing ESSR by this method is that it has already been field-tested to determine the effect of the stocking rate on rangelands. The combination approach described above plus periodic monitoring allows RMB to determine a conservative ESSR, which accounts for the variation inherent in biological systems, and is sustainable over time.

Monitoring is a key component of range management. It is important to monitor the rangeland resource to see if goals are being achieved and if changes in management, including stocking rates, are necessary. Monitoring can be in the form of an inventory or a health assessment. Periodic monitoring of range vegetation is essential for a number of reasons [Robertson and Adams 1990]. These include: 1. To detect changes in the plant community or plant composition which affect the health of rangeland 2. To detect changes in plant composition which are normally slow and may be quite subtle, and 3. To supplement management knowledge since

livestock production is not a sensitive indicator of the health of rangeland. SRD has established the Rangeland Reference Area Program where continuous monitoring of species composition and production has been conducted in the presence and absence of grazing [Rangeland Management Branch 2004]. This monitoring information together with detailed range inventories has allowed SRD to develop ecological classifications, determine the health of rangelands, and provide the basis for determining ESSRs on public land.

2. Range Vegetation Classification System and Plant Community Guides[3]

In order to manage vegetation for range, timber, wildlife and recreation the ecology of the plant communities in the presence and absence of disturbance must be understood. Vegetation classification helps to reduce the complexity of natural vegetation to a manageable number of similar groups, often called **plant community types**. These community types are defined not only by their vegetation composition but also by the environmental conditions under which they occur.

Two major classification tools are commonly used to assist in the classification process. These include the mathematical approach, which involves the analysis of plant data through measures of dissimilarity or similarity to form plant communities (Gauch 1982) and the ecological landscape classification approach. In the Rocky Mountain, Foothills and Boreal Natural Regions, the Ecological Landscape Classification approach incorporates both vegetation and site conditions [climate, soils and geology] into a hierarchical ecological unit classification [e.g. **subregion**, **ecosite, ecosite phase,** plant community] [Strong and Thompson 1995]. Ecological sites are areas of similar climate, moisture and nutrient regimes that can be further divided into **ecological site phases**, based on dominant tree or shrub species. The lowest taxonomic unit in the classification system is the plant community type based on unique understory species composition within a given ecological site phase. It is at the plant community type level where range ESSR, CC and GC are assessed and monitored.

In grassland areas of Alberta, the system of ecological landscape classification is guided by published soils inventory data [**AGRASID** – Agricultural Region of Alberta Soil Inventory Database] and a similar analytical approach that correlates plant communities with soil features. An important aspect of forest plant community classification is the recognition of forest canopy composition and structure from aerial photography. In grasslands, composition and structure must be inferred from site conditions alone. The hierarchical classification approach used in grasslands, applies the historical range site concept [Smoliak et al. 1966, Wroe et al. 1988] by correlating vegetation with climate and site [soil landscape, soil features and soil texture] [LandWise Inc. 1998, Adams et al. 2003]. The synonymous terminology in grassland compared to forested areas is; range site and ecological site, **ecological range site** and ecological site phase.

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[3] Range Plant Community Guides have, or are in the process of being developed for selected Natural Subregions. For information these guides contact SRD PLFD Rangeland Management Resource Program staff.

SRD RMB have created a range vegetation classification system, based on a plant community type, that combines both the mathematical and ecological landscape classification approaches. As a result range plant community guides have or are currently being developed for each subregion of the province. These guides outline the species composition, production and suggested ESSR [ha/AUM or ac/AUM] of each range plant community. Occasionally, plant communities are encountered for which a detailed plant community description has not yet been developed. In these instances species composition information is collected, production is clipped or estimated and then the suggested ESSR is determined and monitored for appropriateness. In the interim, Rangeland Agrologists determine the ESSR based on field experience.[4] The guides are periodically updated as new information is developed, therefore the latest versions must be used when determining ESSRs.

3. Mapping

Mapping of plant community types allows the range manager to determine the area [ha or ac] of a polygon attributed with a particular ESSR [AUMs/area]. Polygon area, multiplied by the ESSR [expressed as AUMs/area], equals the polygon CC. There are several steps to the mapping process, each step subdividing the previous division. The mapping process begins with the boundary of the area of interest [e.g. lease]. Next, the boundary is subdivided into management units. These are delineated based on fencelines [i.e. pastures] or natural barriers. Management goals and decisions for these units have the potential to have varying effects on plant community succession, rangeland health and therefore productivity. Additionally, management options [e.g. livestock rotations, stocking rates, water development, etc.] are applied on a pasture basis. To maximize resource management effectiveness, management units must be delineated. [Management units of associated private lands used by the livestock operation may also be mapped, but have no impact on the CC of the grazing disposition.]

Next, the lowest known ecological unit [e.g. ecological site phase or plant community] is delineated and mapped in order to determine the area associated with each community type within management units. Spatial data such as soil landscape information [e.g. Physical Land Classification (**PLC**) or AGRASID], vegetation information [e.g. Alberta Vegetation Inventory (AVI)], or aerial photo interpretation are utilized to assist in the identification of relatively contiguous ecological units or 'polygons'.

Once the area of interest is delineated to the most practical level of ecological unit, the boundaries, management units and polygons are digitized to produce a map in ArcView. Data [obtained from a detailed inventory or a health assessment] is associated with each polygon and is used to populate the ArcView attribute table [e.g. Table 1]. Additional spatial data such as

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[4] Additionally, the Rangeland Agrologist may want to adjust the ESSR (value that is automatically brought into GLIMPS from the Guides) based on their field experience or new information not yet incorporated into the Guides. This adjustment is made in the **adjusted stocking rate** column.

AVI or AGRASID can also be linked to each polygon. Once data is associated with a particular polygon, it is mapped in a geographic information system [e.g. ArcView].

Often it will not be possible or desirable to separate out all the plant community types that exist within a mappable unit [minimum size ~ 0.7 cm X 0.7 cm at 1:20,000 or 2 ha]. For example, in the Parkland Subregions, open grassland, shrublands and aspen forest communities can all co-exist within one acre. To allow for this complexity in landform and therefore, plant community types, the ArcView attribute table can accommodate up to three plant community types as mosaics, per polygon. The convention used by RMB to map these plant community mosaics as one polygon employs the use of deciles [portions of 100% recorded as whole numbers from 1 to 10, 10 representing 100%]. A decile is used to describe the relative area occupied by each of the 3 dominant plant community types within the mapped unit. Table 1 shows a format that can be used to record the information. The fields named with "_1" are associated with the first decile, while "_2" and "_3" [not shown in the table] would be the second and third deciles. Continuing with the Parkland example, a delineated polygon might be comprised of 50% rough fescue community [in decile_1 enter 5]; 30% buckbrush community [in decile_2 enter 3]; and 20% aspen-rose community [in decile_3 enter 2]. The CC for each polygon is determined by dividing area [e.g. ha or ac] by stocking rate [ha/AUM or ac/AUM] for each decile, then summing the AUMs of all the deciles within the polygon.

These mapping procedures and calculations can be done by hand, within GLIMPS [mapping function under development] or ArcView.

Table 1: Example **rangeland unit** attribute table for mapping and calculation of CC and GC

FIELD_NAME	VALUES
Polygon_no	**Polygon Number**: Unique identifying number or character for the delineated polygon.
Decil_1	**Decil**: Use 1,2,3…10 indicating the percentage of the polygon the decile occupies i.e. 3 = 30%.
Ecosite_1 or Range Site_1	**Ecological site**: One character as per the plant community guides [e.g. c]. **Range Site:** Two or three characters as per plant community guides [e.g. Bdl]
Eco_phas_1 or Ecological Range Site_1	**Ecological site Phase**: Two characters as per the plant community guides [e.g. c3] **Ecological Range Site_1**: Two or three characters as per plant community guides [e.g. a21]
PC_1	**Plant Community Code**: Enter the code taken from a plant community guide. If the plant community has not yet been described in any plant community guide, enter CPC and a number for conditional plant community proposed. CPC# is not required in GLIMPS.
Sugg_Stock_1	**Suggested Ecologically Sustainable Stocking Rate**: taken from the Range Plant Community Guides [e.g. 2.0 ha/AUM].
Adj_Stock_1	**Adjusted Stocking Rate:** entered when the suggested ESSR does not represent the site (based on field experience or new data) [e.g. 2.5 ha/AUM]. If the ESSR does not currently reflect a reduction in stocking level to improve range health, adjustments should be made here.
Carry_Cap_1	**Carrying Capacity:** ESSR expressed for the polygon area [AUMs]. Note that this value is not displayed in GLIMPS.
Rge_Use_1	**Range Use Category**: 1-Primary, 2-Secondary, 3-Non-use, 4-Special Use.
Access_Factor_1	**Access Factor:** Accessibility of a rangeland unit to livestock under practical range management. Enter "0" for no access, up to "10" for complete access [e.g. 7 = 70% of unit is accessible to livestock]
Bill_AUMs_1	**Billable AUMs:** In the RMF within GLIMPS, this value is referred to as 'Carrying Capacity'. Expressed as AUMs. See glossary for further information.
Mgm_Factor_1	**Management Factor**: The portion of a rangeland unit used by livestock under current management [i.e. livestock distribution]. Enter "0" for very poor distribution, and up to "10" for full livestock distribution [e.g. 7=70% of rangeland unit is traversed by cattle].

Graz_Cap_1	**Grazing Capacity:** GC = [CC X access factor X management factor]. Expressed as AUMs.
ST_Factor_1	**Short-Term Factor:** adjustment for factors that impact production on a short-term basis. 0 to 100 where "0" = complete short-term loss of production, "10" = 100% of long-term production, "11" = 10% short-term increase in production, "20" = 200% short-term increase in production [or 2 times the long-term production].
ST_Factor_Reas_1	**Short-Term Factor Reason:** justification for short-term change in grazing capacity. 1 = Drought, 2 = Flood, 3 = Grasshoppers, 4 = Other.
ST_Graz_Cap_1	**Short-Term Grazing Capacity:** is equal to the GC multiplied by the Short-term Factor. Expressed as AUMs.
Descript_1	**Description**: description of the plant community type by dominant species.
Guide_1	**Field Guide and version used**: Enter Subregion code [e.g. Lower Foothills = LF] and version number [e.g. second approximation =2]. **Range Guides**: e.g. LF#, UF#, DM&CMW#, DMG#, etc. **Ecosite Guides**: NN, WC or SW
Map_Label	**Map Label**: Complete this based upon the Plant Community code for each decile. GLIMPS automated, can be populated automatically within ArcView as well. Enter the combination of the decile percent value [e.g. 7=70%] and the plant community code for that decile. [e.g. 8e5 2DMC4 is a polygon with 2 deciles – 80% is plant community e5 and 20% is plant community DMC4.]
Rge_Hlth	**Range Health Score**: Consists of the last 2 digits of the current year, followed by a dash, followed by the percentage [e.g. 00-66]. GLIMPS automated.
Source	**Source:** Initials of user entering this data - 2 characters only [e.g. CL]

Note: All numbered field names are repeated for up to 3 deciles [i.e. Decile_2, Ecosite_2, Eco_phase_2, etc.]

4. Carrying and Grazing Capacity

The CC for a grazing disposition of a given size represents the maximum number of AUMs that can be sustained without causing a downward trend in rangeland health. Suggested ESSR values provided in the plant community guides are determined from a combination of clipping studies, long-term rangeland reference area data, estimated production, and historical grazing experience. In order to sustain ecological health and function of the plant community, ESSRs are based on standardized biomass allocation and forage requirements of one **animal unit** [i.e. 455 kg of dry matter per month]. For calculation purposes CC = [Area divided by ESSR (in area/AUM)].

The 'standardized' forage allocation varies with subregion and is prescriptive based on the ecological needs of the site. For example, the allocated biomass for livestock use is 25% of total production for forested plant community types, and 50% of total production for grass and shrub land types within the Boreal and Foothills **Natural Regions**. Willoughby [1995] has found on forested grazing dispositions where livestock use exceeded the calculated CC based on 25% of total production, there were a higher proportion of unhealthy communities. In contrast, on dispositions where livestock use was less than the calculated CC there was a higher proportion of healthy forest types. On some grasslands in the foothills of southwestern Alberta, where 50% of total production is used in the calculation of CC, Willoughby [1997a,b], Willoughby and Weerstra [1997] have found that the grassland plant species diversity has improved on rangeland reference areas where livestock use is at or below the calculated CC for at least 10 years.

On prairie rangelands, long-term grazing records and range condition estimates [now termed range health] have been employed to establish sustainable CC values [Clark et al. 1942, Johnston et al. 1971, Willms et al. 1985, Wroe et al. 1988]. Recommended utilization levels are generally considered to range between 25 to 50% of total production depending on the ecological site. At Stavely, stocking rates that sustained CC involved utilization levels of about 40% [Willms et al. 1995]. Within the Foothills Fescue, harvest rates of 50% are only possible under careful winter

grazing management [Willms et al. 1995]. In the Dry Mixedgrass, a review of historical stocking rates over the past 35 years has demonstrated that stocking rates considered sustainable for solonetzic soils, appear to harvest at about 25 to 35% of total production [Adams et al. 2004a].

Based on current information, SRD RMB allocates 25% of the total production in forest rangelands[5], 25 to 50% of the total production in native grass rangeland, and 40 to 70% of the total production in a tame pasture for livestock use when determining stocking rate. These percentages of production use are called **safe use factors**. Continued monitoring of rangeland reference areas and the use of the rangeland health assessment short forms, will assist in verifying or adjusting present safe use factors and stocking rate calculations. With this approach, estimating the actual amounts of production utilized will be less important than estimating a long-term stocking rate that maintains or improves range health. The remaining biomass production [carry over] is allocated for the maintenance of ecological functions [e.g. nutrient cycling, viable diverse plant communities, hydrological function, soil protection, etc.], and plant community services [forage production, habitat maintenance, wildlife forage use, etc.]. The allocation of biomass production in this manner is well established and supported by the scientific community [Holechek et al. 1995].

SRD calculates grazing disposition rental fees based on the long-term livestock grazing potential of the disposition and therefore is derived from only those AUMs in areas that can be grazed with practical management [i.e. **primary** and **secondary range**]. In the **RMF** within GLIMPS, this value is displayed as 'Carrying Capacity' however it represents **Billable AUMS**. For calculations, Billable AUMs = [CC X access factor]. The access factor is used to adjust the CC by removing AUMs from productive polygons [or portions of] that are inaccessible [i.e. **non-use range**] to livestock due to natural barriers [e.g. cliffs, large rivers or water bodies, heights of land, slopes, dense understory vegetation or dense forest]. The access factor may also be used to exclude those areas where livestock grazing is not desirable [i.e. special use range] due to the area's sensitive nature and/or value to wildlife [i.e. some subalpine grasslands important to Big Horn Sheep, riparian areas that are identified as fish spawning sites, etc.].

Often the CC must be further adjusted not only for access factors [e.g. areas that are inaccessible due to natural barriers], but also for management factors [e.g. reduced livestock distribution attributed to livestock management]. This adjusted/reduced carrying capacity is the grazing capacity [GC]. For example, a livestock producer who is not effectively using range management tools and techniques to modify stock distribution will find grazing pressure is confined to primary range [i.e. preferred areas]. In some situations the GC maybe based only on the capacity of the primary range, which could be well below the potential [i.e. CC]. Livestock utilization of secondary range is also included in the calculation of GC by the Rangeland Agrologist. The adjustment to GC reflects the relatively light use of secondary areas (typically anywhere between 5%-95%). This approach (i.e. the management factor adjustment) allows the

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[5] NOTE: In forested rangelands, the allocation of 25% of total production is approximately equal to 50% of usable [i.e. production palatability of fair or better]. If the palatability of the production on the site is primarily poor, the percent allocated to livestock should be reduced accordingly.

SRD Rangeland Agrologist to consider grazing season, rotation and animal behaviour patterns when setting a GC. For calculations GC = [CC X access factor X management factor].

The GC represents the approved AUMs or stocking level, and is applied to the disposition to prevent over-grazing on primary range. This adjusted/reduced value reflects the area of land that is being used by livestock based on the current level of management and livestock distribution[6].

CC and GC are meant to represent the long-term grazing potential of the site, not the periodic fluctuations in production that may be observed at the time of assessment. Rangeland Agrologists can document temporary changes in production due to: drought, flooding, fire, pests, disease, fertilizer etc., by using a **short-term factor**. This factor can be used to increase or decrease GC to arrive at a **short-term grazing capacity**. The short-term grazing capacity should be used to determine temporary stocking levels and does not affect the long-term CC, Billable AUMs or GC.

Sample Calculation for Forested Rangelands

Given the following example of a grazing disposition where seven range plant community types were identified according to the Range Plant Community Types and Carrying Capacity Guide for the Lower Foothills Subregion – 3rd Approximation [2000] [see Table 2 and Figure 1] during a health assessment. Only five of these community types are suitable for domestic livestock grazing. For this example stocking rates for most of the polygons were derived from the guide, however the stocking rates for the final three polygons were estimated by an experienced Rangeland Agrologist. Remember that the guidelines suggest 25% allocation of the total production from forest, and 40 to 70% allocation from areas cleared and seeded to tame species to contribute to the ESSR of a given plant community type.

The following calculation example uses information and values from Table 2.

POLYGON INFORMATION:

Polygon No. 39 Map label 8e5 2DMC4 68.3 hectares [ha]
This map label [8e5 2DMC4] represents a complex of two unique plant community types, comprised of 80% Aw/alder [e5] and 20% Aw/rose-beaked hazelnut [DMC4].
An animal unit month [AUM] forage requirement is 455 kg [1000 lb.] of forage to feed a 455 kg [1000 lb.] cow +/- calf for one month expressed as 455 kg/AUM.

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[6] Although it is generally expected that all disposition holders could achieve an GC equal to the billable AUMs, extenuating circumstances such as herd size, financial position, holistic management goals, etc. may make it impractical or undesirable.

Calculation of CC, Billable AUMs, GC and Short-term GC

Decile_1: Aw/alder [e5]:

Area = 68.3 ha X 0.80 of the polygon = 54.6 ha
Total understory production = 861 kg/ha
Safe Use Factor within forested plant community types = 25%
ESSR = 455 kg/AUM / [861 kg/ha X 25%] = 2.1 ha/AUM
CC = area / ESSR = 54.6 / 2.1 = 26 AUMs
Access factor = 90%
Billable AUMs = CC X 90% = 23.4 AUMs
Management factor = 80%
GC = Billable AUMs X 80% = 18.7 AUMs
Short-term factor = 100%
Short-term GC = GC X 100% = 18.7 AUMs

Decile_2: Aw/rose-beaked hazelnut [DMC4]:

Area = 68.3 ha X 0.20 of the polygon = 13.7 ha
Total understory production = 1010 kg/ha
Safe Use Factor within forested plant community types = 25%
ESSR = 455 kg/AUM / [1010 kg/ha X 25%] = 1.8 ha/AUM
CC = area / ESSR = 13.7 / 1.8 = 7.6 AUMs
Access factor = 90%
Billable AUMs = CC X 90% = 6.8 AUMs
Management factor = 50%
GC = Billable AUMs X 50% = 3.4 AUMs
Short-term factor = 100%
Short-term GC = GC X 100% = 3.4 AUMs

Polygon 39 **CC** = e5 + DMC4 = 26 AUMs + 7.6 AUMs = 33.6 AUMs
Billable AUMs = e5 + DMC4 = 23.4 AUMs + 6.8 AUMs = 30.2 AUMs
GC = e5 + DMC4 = 18.7 AUMs + 3.4 AUMs = 22.1 AUMs

Table 2. Range plant community types, suggested stocking rates, CC , Billable AUMs, GC and Short-term GC for a given grazing disposition. [Range Plant Community Types and CC Guide for the Lower Foothills Subregion – 3rd Approximation [2000].]

Polygon No.	Map Label	Range Plant Community Type	Area [ha]	ESSR [ha/AUM]	CC [AUMs]	Access Factor [%]	Billable AUMs	Mgmt. Factor [%]	GC [AUMs]	Short-term Factor [%]	STGC [AUMs]
40	a1	Creeping red fescue-timothy/clover	8.3	0.3	27.7	100	27.7	100	27.7	30	8.3
55a	a6	Marsh reedgrass /rose/strawberry-dandelion	2.4	0.5	4.8	100	4.8	100	4.8	100	4.8
55b	a6	Marsh reedgrass /rose/strawberry-dandelion	2.0	0.5	4	100	4	100	4	100	4
39	8e5 2DMC4	80% Aw/alder 20% Aw/rose-beaked hazelnut	54.6 13.7	2.1 1.8	26 7.6	90 90	23.4 6.8	80 50	18.7 3.4	100 100	18.7 3.4

52	h7	Aw-Pb-Sw/alder	4.6	3.0	1.5	20	0.3	100	0.3	100	0.3
54	h7	Aw-Pb-Sw/alder	20.6	3.0	6.9	60	4.1	100	4.1	100	4.1
56	h7	Aw-Pb-Sw/alder	3.8	3.0	1.3	80	1	100	1	100	1
58	h7	Aw-Pb-Sw/alder	9.8	3.0	3.3	60	2	100	2	100	2
33	j10	Pl-Sw / twinflower/moss	2.5	0.0	0	100	0	0	0	100	0
59	j12	Sw/moss	24.9	0.0	0	100	0	0	0	100	0
55a	Well		0.7	0.0	0	100	0	100	0	100	0
	Total*		**146**		**83**		**74**		**66**		**47**

*Numbers are rounded to the nearest whole number.

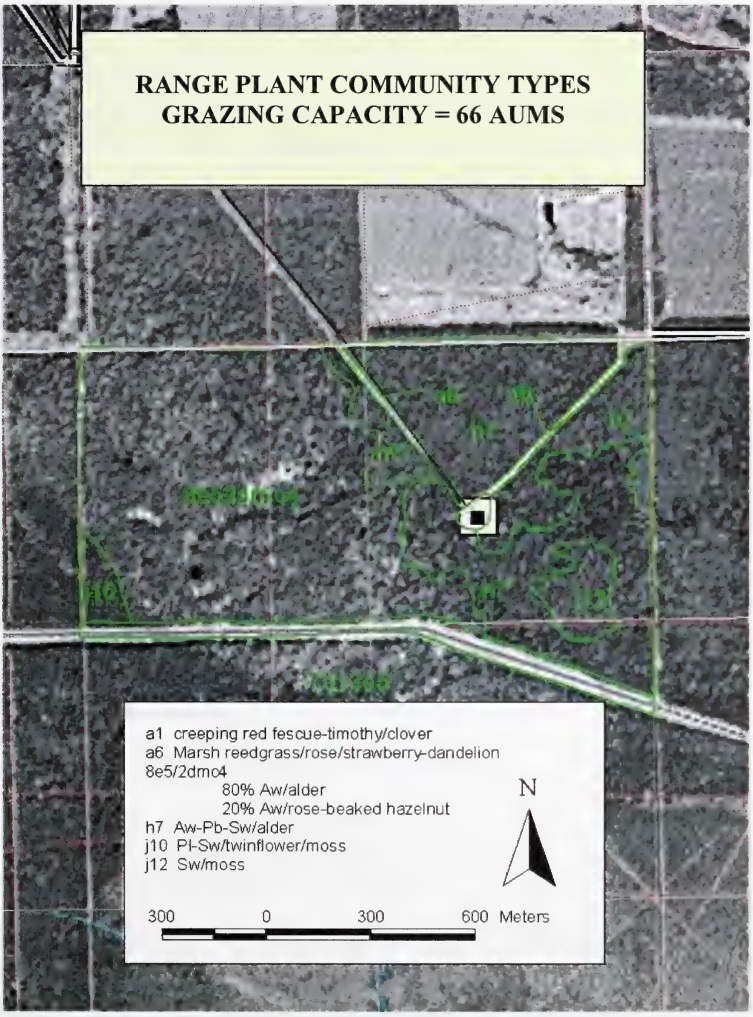


Figure 1 Example of delineated forest vegetation polygons.

Sample Calculation for Grassland Rangelands

In the following example of a grazing disposition, five range plant community types were identified according to the Range Plant Communities and Range Health Assessment Guidelines for the Mixedgrass Natural Subregion of Alberta – 1st Approximation [2004] [see Table 3 and Figure 2] during a health assessment of a small grazing disposition. In this example, the guidelines in the plant community guide were applied to the first four polygons, based on historical records in the guide that have been demonstrated to sustain rangeland health. The fifth polygon is estimated based on a 40% level of utilization from ocular estimates of productivity.

The following calculation example uses information and values from Table 3.

POLYGON INFORMATION:
Stocking rates for polygons 1, 2, 3 and 4 are taken from the plant community guide. Polygon 4 requires weighting for deciles, access and management factors which is illustrated in the following calculations:

Polygon No. 4 Map label 7a21 3c4 65 acres [ac]
This map label [7a21 3c4] represents a complex of two unique plant community types, comprised of 70% Wheat grass-Needle and Thread [a21] and 30% Snowberry/Needle and Thread-Low Sedge [c4].

Calculation of CC, Billable AUMs, GC and Short-term GC

Decile_1: Wheat grass-Needle and Thread [a21]
Area = 65 ac X 0.70 of the polygon = 45.5 ac
ESSR from plant community guide = 0.28 AUM/ac.
CC = ESSR X area = 45.5 X 0.28 = 12.7 AUMs
Access factor = 95%
Billable AUMs = CC X 95% = 12.1 AUMs
Management factor = 90%
GC = 12.1 X 90% X 100% = 10.9 AUMs
Short-term factor = 100%
Short-term GC = GC X 100% = 10.9 AUMs

Decile_2: Snowberry/Needle and Thread-Low Sedge [c4].

Area = 65 ac X 0.30 of the polygon = 19.5 ac
ESSR from plant community guide = 0.24 AUM/ac.
CC = ESSR X area = 19.5 X 0.24 = 4.7 AUMs
Access factor = 50%
Billable AUMs = CC X 50% = 2.4 AUMs
Management factor = 50%
GC = 2.4 X 50% X 100% = 1.2 AUMs
Short-term factor = 100%
Short-term GC = GC X 100% = 1.2 AUMs

Polygon 4 **CC** = a21+ c4 = 12.7 AUMs + 4.7 AUMs = 17.4 AUMs
Billable AUMs = a21 + c4 = 12.1 AUMs + 2.4 AUMs = 14.5 AUMs
GC = a21 + c4 = 10.9 AUMs + 1.2 AUMs = 12.1 AUMs

Polygon No. 5 Map label b5 50 acres [ac]

CALCULATION OF CC, Billable AUMs AND GC

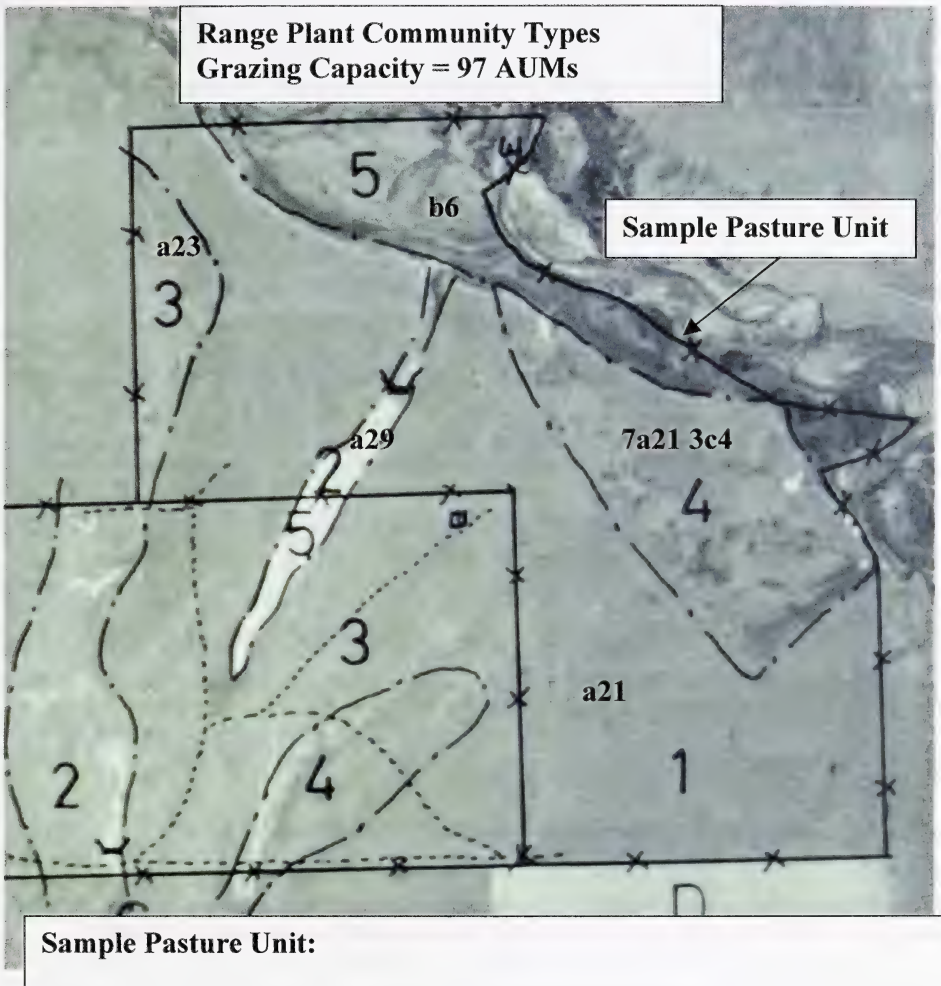
Area = 50 ac
Total estimated production = 900 lb/ac
Safe Use Factor for a modified plant community type = 40%
ESSR = [900 lb/ac X 40%]/1000 lb/AUM = 0.36 AUM/ac
CC = ESSR X area = 50 X 0.36 = 18 AUMs
Access factor = 85%
Billable AUMs = CC X 85% = 15.3 AUMs
Management factor = 50%
GC = CC X 50% X 100% = 7.7 AUMs
Short-term factor = 70%
Short-term GC = GC X 70% = 5.4 AUMs

Polygon 5 **CC** = b6 = 18 AUMs
Billable AUMs = b6 = 15.3 AUMs
GC = b6 = 7.7 AUMs

Table 3. Range plant community types, suggested stocking rates, CC, Billable AUMs, GC and Short-term GC for a given grazing disposition. Range Plant Communities and Range Health Assessment Guidelines for the Mixedgrass Natural Subregion of Alberta – 1st Approximation [2004]

Polygon No.	Map Label	Range Plant Community Type	Area [ac]	ESSR [ac/AUM]	CC [AUMs]	Access Factor [%]	Billable AUMs	Mgmt. Factor [%]	GC [AUMs]	Short-term Factor [%]	STGC [AUMs]
1	a21	Wheat grass – Needle and Thread	255	0.28	71.4	100	71.4	100	71.4	100	71.4
2	a29	Salt Grass-Foxtail Barley-Western Wheat grass	8	0.2	1.6	100	1.6	100	1.6	100	1.6
3	a23	Blue grama grass-Needle and Thread	20	0.2	4	100	4	100	4	100	4
4	7a21	Wheat grass – Needle and Thread	45.5	0.28	12.7	95	12.1	90	10.9	100	10.9
	3c4	Snowberry/Needle and Thread-Low Sedge	19.5	0.24	4.7	50	2.4	50	1.2	100	1.2
5	b6	Snowberry/Crested Wheat grass-Pasture Sagewort	50	0.36	18	85	15.3	50	7.7	70	5.4
	Total*		**398**		**112**		**107**		**97**		**95**

* AUMs are rounded to the nearest whole number.



Sample Pasture Unit:

a21	Loamy 3	MGA21 Wheat grass-Needle and Thread
a23	Loamy 3	MGA23 Blue grama grass-Needle and Thread
a29	Saline Lowlands3	MGA29 Salt Grass-Foxtail Barley-Western Wheat grass
b6	Loamy 7	MGB6 Snowberry/Crested Wheat grass-Pasture Sagewort
c4	Loamy 7	MGC4 Snowberry/Needle and Thread-June Grass

Figure 2. Example of delineated grassland vegetation polygons.

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APPENDIX 1. Glossary of Terms

Access Factor. A value used by Rangeland Agrologists to reduce the CC to obtain billable AUMs for a grazing disposition. It is the percentage of the rangeland unit that is accessible to livestock under practical management. The access factor is used to remove AUMs from productive polygons [or portions of] that are inaccessible [i.e. non-use range] to livestock due to natural barriers [e.g. cliffs, large rivers or standing water, heights of land, slopes, dense understory vegetation or dense forest]. The access factor may also be used to exclude those areas where livestock grazing is not desirable [i.e. special use range] due to the areas sensitive nature and/or value to wildlife [e.g. some subalpine grasslands important to Big Horn Sheep, riparian areas that are identified as fish spawning sites, etc.]. It is one of two factors that are used to adjust CC to obtain GC.

Adjusted Stocking Rate. An adjustment made to the suggested ESSR for a particular plant community type obtained from a Range Plant Community Guide. The adjustment is made when the value in the guide is not representative of the site based on new data, or field experience, or if the ESSR does not currently reflect a reduction in stocking level to improve range health. The RA is required to document any changes made to the stocking rate.

AGRASID. Agricultural Region of Alberta Soil Inventory Database. This database is in the GIS environment and is made up of relational data files. This database is employed to determine range site (ecological site) type in grassland areas of Alberta.

Animal Unit [AU]. The standard animal unit represents the forage requirement equivalent of one mature cow of approximately 1000 lbs. [455 kg] either dry or with calf up to 6 months of age. **AU equivalents** are conversions of non-standard animals [e.g. different animal species] and size [e.g. cows over 1000 lbs] based on metabolic requirements. For example, 1 AU equals 1 1000 lb cow, or 5 sheep or 74% of a 1350 lb cow [which is alternatively 1.35 AUs]. Typically, 1 AU will require 26.5 lbs [12 kg] of dry matter per day plus some allowance for trampling loss.

AUM. The amount of forage required by 1 animal unit for 30 days. It is often expressed as a stocking rate [AUM/ha or ac]. Generally, 1 AUM will require 1000 lbs [455 kg] of dry matter per month that includes a 25% forage loss due to trampling.

Billable AUMS. To determine billable AUMs, the CC is reduced to represent the long-term livestock grazing potential of the disposition and only includes AUMs from those areas that can be grazed with practical management. For calculations, Billable AUMs = [CC X access factor].

Carrying Capacity (CC). The maximum number of AUs that can be supported by a rangeland unit [i.e. pasture, plant community or vegetation polygon] of a given size and for a given period of time. CC is calculated from the ESSR and is expressed in terms of AUMs for the rangeland unit. For calculation purposes CC = [Area divided by ESSR (in area/AUM)] or [Area multiplied by ESSR (in AUM/area)].

- Example #1: If the size of rangeland unit #1 is 80 ac and the assigned ESSR is 1.0AUM/ac, then rangeland unit #1 CC equals 80 AUMs (80 ac X 1.0AUM/ac).

- Example #2: If the size of rangeland unit #2 is 40 ha and the assigned ESSR is 1.8 ha/AUM, then rangeland unit #2 CC equals 22 AUMs (40 ha ÷ 1.8ha/AUM).
- If rangeland units 1 and 2 in the preceding examples make up the entire management unit [e.g. ranch or lease] then the CC for the entire management unit is 102 AUMs (80+ 22).

Ecodistrict. The first subdivision of Subregion based on distinctive physiographic and/or geographic patterns.

Ecological Site. Term used in Rangeland Classification system that is synonymous to **Ecosite**. This new term is used to provide subtle distinction to recognize the blending of the old systems and still be recognizable to readers familiar with the original terminology. See also **Ecological Range Site**.

Ecological Site Phase. Term used in Rangeland Classification system that is synonymous to **Ecosite Phase**. This new term is used to provide subtle distinction to recognize the blending of the old systems and still be recognizable to readers familiar with the original terminology.

Ecologically Sustainable Stocking Rate (ESSR). Represents the maximum number of AUMs for a given plant community or vegetation polygon that can be sustained without causing a downward trend in rangeland health. ESSRs take into account the inherent biophysical constraints, the ecological goals of sustainable health and proper functioning and the long term grazing potential of the unit. ESSRs are usually expressed as animal unit months - [AUM]/area [ac or ha] or area [ac or ha]/AUM [e.g. 1.0AUM/ac or 0.4 ha/AUM]. GLIMPS automatically enters the ESSR from the ESD database. If the Rangeland Agrologist would like to change the ESSR, see the Adjusted Stocking Rate definition.

Ecological Range Site. In the classification of plant communities in the grasslands of Alberta, an **ecological range site** represents the subdivision of a **range site** into recognizable reference plant communities (see **Reference Plant Community** and **Range Site**). Loamy sites near the moist end of the natural subregion might be described, as Loamy 1 and the driest in the sequence would be Loamy^{n}. An **ecological range site** then would be the combination of the plant community name and the subdivision of the range site by plant community (Loamy 1 - Plains Rough Fescue - Western Porcupine Grass). This new term is used to provide subtle distinction to recognize the blending of the old system of range site classification established by Smoliak et al. 1966 and Wroe et al. 1988 and still be recognizable to readers familiar with the original terminology.

Ecosite. A functional ecological unit that develops under similar environmental influences [climate, moisture and nutrient regime]. Each ecosite is designated by a lower case letter and further named by a common plant species typical of the site [e.g. d low bush cranberry]. Ecosites are named from driest to wettest. An 'a' would indicate a drier site than 'g' for example. Ecosites are groups of ecosite phases. An ecological site is defined by the Task Group on Unity and Concepts (1995) as, "*a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation*".

Ecosite Phase. A subdivision of ecosite primarily based on the dominant species in the highest plant layer but may also be influenced by lower strata plant species abundance and pedogenic processes.

Forage. All browse and non-woody plants that are available and palatable to domestic livestock or wildlife.

GLIMPS. Geographic Land Information and Management Planning System used by SRD PLFD to store resource management information.

Grazing Capacity (GC). This value represents the AUMs or stocking level for a rangeland unit [e.g. pasture or disposition] and is applied to prevent over-grazing on primary range. The GC includes adjustment to CC for: 1) livestock access (access factor) and 2) Livestock distribution (management factor). For calculations GC = [CC X access factor X management factor].

Management Factor. A value used by Rangeland Agrologists to reduce the CC to represent the percentage of the rangeland unit that is used sustainably by livestock under current management. It is one of two factors that are used to adjust CC to obtain GC. For example, a livestock producer who is not effectively using range management tools and techniques to modify stock distribution will find grazing pressure confined to primary range with minimal use of secondary range. In order to avoid overuse of primary range the Rangeland Agrologist will reduce the stocking of the disposition by using a management factor.

Natural Region. Provides an overview of the landscape. Each Natural Region contains a combination of similar vegetation, soil and landforms features. [e.g. Boreal Forest Natural Region]

Non-use range. Rangeland that goes unused by livestock, even when primary and secondary ranges are over-utilized.

Plant Community Types. Within forested plant communities, a subdivision of ecosite phase [or ecological site phase] based on differences in understory species composition and abundance. Generally, plant communities are named by combining the ecosite phase name with a dominant plant species in each structural layer. In the grasslands of Alberta, plant communities are a subdivision of range site type based on dominant and/or indicator plant species. Generally, plant communities are named by combining the range site name with a dominant plant species in each structural layer.

PLC. Physical land classification describes landform, surface expression, parent material, soil texture, slope, aspect, and drainage within a polygon.

Primary Range. The area of rangeland that animals prefer to graze when management is minimal.

RMF. Range Management Form used in GLIMPS by Rangeland Agrologists to record resource information and to determine Billable AUMs and Grazing Capacity.

Range Health. The rating of the ability of rangeland to perform certain ecological functions including: net primary production, maintenance of soil/site stability, capture and beneficial release of water, nutrient and energy cycling and plant species functional diversity. Range health categories include: Healthy, Healthy with problems, and Unhealthy. Healthy rangelands will provide sustainable grazing opportunities for livestock producers and also sustain a long list of others products and values. Declines in range health will alert the range manager to the need for management changes. For a detailed description on how to assess rangeland health for various plant communities please refer to "*Rangeland Health Assessment for Grassland, Forest and Tame Pasture*", [Adams, B.W., G. Ehlert, C. Stone, D. Lawrence, M. Alexander, M. Willoughby, C. Hincz, D. Moisey, and A. Bogen. 2004. Rangeland Health Assessment for Grassland, Forest and Tame Pasture. Alberta Sustainable Resource Development. Public Lands Division. Edmonton. AB. Pub. No. T/044. 104pp.] NOTE: If the ESSR does not currently reflect a reduction in stocking level to improve range health, changes should be made to the adjusted stocking rate.

Rangelands. Areas of the world, which by reason of physical limitations (low and erratic precipitation, rough topography, poor drainage, or cold temperatures) are unsuited to cultivation, and which are a source of forage for free-ranging native and domestic animals, as well as a source of wood products, water, and wildlife.

Rangeland Management. A distinct discipline founded on ecological principles and dealing with the use of rangelands and range resources for a variety of purposes. These purposes include use as/for grazing by livestock, watersheds, wildlife habitat, recreation, and aesthetics, as well as other associated uses and values.

Rangeland Unit. Any delineated landscape area separated from the surrounding area to facilitate management [e.g. pasture, lease, ecological site phase, plant community or other biophysical polygon].

Range Site. Within a natural subregion, a stratification of rangeland based on site characteristics of landscape, soil features and soil texture (Landwise Inc. 1998) and are described in 14 categories using range site names that convey important site characteristics that influence vegetation development and site potential and are easily recognized by names like overflow, loamy, blowout, sandy etc. (Landwise Inc. 1998). **Ecological range sites** result when range sites are further subdivided into recognizable reference plant communities (see Ecological Range Site). Like the concept of **ecosite** employed in forested rangeland classification, the concept of **range site** applied in the Grassland Natural and Central Parkland Natural Regions (Smoliak et al. 1966 and Wroe et al. 1998) is a functional ecological unit that develops under similar environmental influences [climate, moisture and site conditions]. The concept of **range site** is similar to that of **ecological site** as defined by the Task Group on Unity and Concepts (1995) as, "*a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation*".

Reference Range Plant Community [RPC]. A specific plant community that is chosen to represent an ecological standard based on a given management goal/decision. This RPC is

selected from a number of successionally related plant communities described within an ecological site.

RMB. Rangeland Management Branch within the Public Lands and Forests Division of Sustainable Resource Development.

Safe Use Factor. A value used by SRD PLFD to obtain a **suggested** Ecologically Sustainable Stocking Rate which is reported in the rangeland plant community guides. It is the percentage of the total biomass production of the ecological site that is available for utilization by livestock. The safe use factor considers the given inherent biophysical constraints and the ecological goals of sustainable health and proper functioning of the rangeland unit. The remaining biomass production [carry over] is allocated for the maintenance of ecological functions [e.g. nutrient cycling, viable diverse plant communities, hydrological function, and soil protection, etc.], plant community services [forage production, habitat maintenance, wildlife forage use, etc.]. The allocation of biomass production in this manor is well established, and supported, by the scientific community. Recommended safe use values vary depending on the ecological site and management.

Secondary Range. Rangeland that is lightly used or unused by livestock under minimal management and without special management will ordinarily not receive much use until primary range has been over-utilized.

Short-term Factor. A factor used by Rangeland Agrologists [RA] to document short-term fluctuations in production and to determine temporary stocking levels appropriate for current conditions. It can be used to account for short-term (< renewal period) increases or decreases in grazing potential due to: drought, fire, insects, disease, fertilizer etc. The short-term factor has no impact on the long-term CC, Billable AUMs or GC. If there are long-term effects on production, the adjustment should be made to the ESSR and the RA must provide documentation to verify the change.

Short-term Grazing Capacity. Is derived by the following calculation:
STGC = [GC X Short-term Factor]. See **Short-term Factor**.

SRD. The Ministry of Sustainable Resource Development.

Stocking Rates. The amount of land allocated to each animal unit for the entire grazeable period of the year, (e.g. ha/AUM). Stocking rates can also be expressed as the number of AU/area, AUdays/area, AUM/area, or AUyears/area. Any calculation using stocking rates should consider how the value is expressed and adjust the formulas as required [e.g. see CC]

Subregion. The first division of Natural Regions based on areas of similar landscape patterns that are distinct from other Subregions.

APPENDIX 2. Grazing capacity integrated with reforestation.

The ecological landscape classification system provides a consistent hierarchical system for classifying vegetation within forested landscapes. The range vegetation classification system has linked grazing capacity to this hierarchical system. This provides for a better understanding between the two sectors on resource use levels and a means for allocating the resources in a sustainable manner. Timber operators often manage at the stand level or ecosite phase level, whereas grazing operators manage at the plant community type level.
For example:

Ecosite phase
a mature aspen stand on a moderately-well drained site in the Lower Foothills Subregion.

Plant Community Type
AUMs are assessed based on understory production levels and are expressed as stocking rates, i.e. Aspen/low bush cranberry/tall forbs at 1.9 ha/AUM.

Integrated resource assessment based on site potential, sustainable timber [m^3] and grazing [AUMs].

The forest sector's legal requirement to meet provincial forest regeneration standards is outlined in the Alberta Regeneration Survey Manual [2003]. As a result there is concern from the forest industry regarding livestock use on regenerating cutblocks. Recent studies have shown that grazing and timber harvesting objectives in deciduous forests can be compatible [Lane 1998] if AUM calculations are based on the production in the mature stand prior to harvest. This conservative approach to production allocation in deciduous cutblocks is based primarily on the palatability of unlignified deciduous seedlings to livestock.

Coniferous timber harvest and grazing can also be compatible however studies indicate that coniferous seedling damage in grazed areas is due primarily to incidental trampling rather than livestock browsing [Korpela et al. 2003]. Coniferous cutblocks on average produce three times the forage produced by the mature conifer forest and therefore can provide valuable grazing opportunities for domestic livestock. A conservative allocation of 25% of total production on coniferous cutblocks, once average tree height is greater than 50 cm (to minimize trampling damage), is recommended.

In both coniferous and deciduous cutblocks forage production reaches its maximum approximately 3 years post harvest, however the forage produced by a cutblock is temporary as over time, competition from the forest regeneration reduces understory production and impedes livestock access to forage. The temporary changes in production in both deciduous and coniferous cutblocks must be well managed, should consider reforestation objectives, should not exceed the recommended production allocation for each type and should only be allocated if

grazing management on a disposition is co-ordinated with timber harvesting and silviculture operations. Guidelines for integrating timber harvesting and livestock grazing are available from your Public Lands and Forests Division office [LFD, 2002 and ASRD, 2003].

APPENDIX 3. Stocking rate Conversions

STOCKING RATES

AUM/ac	AUM/ha	ac/AUM	ha/AUM	ac/AUyr	ha/AUyr	AUD/ac	AUD/ha
0.04	0.10	25.00	10.1	300.0	121.4	1.2	3.0
0.05	0.12	20.00	8.09	240.0	97.1	1.5	3.7
0.10	0.25	10.00	4.05	120.0	48.6	3.0	7.4
0.15	0.37	6.67	2.70	80.0	32.4	4.5	11.1
0.20	0.49	5.00	2.02	60.0	24.3	6.0	14.8
0.25	0.62	4.00	1.62	48.0	19.4	7.5	18.5
0.30	0.74	3.33	1.35	40.0	16.2	9.0	22.2
0.35	0.86	2.86	1.16	34.3	13.9	10.5	25.9
0.40	0.99	2.50	1.01	30.0	12.1	12.0	29.7
0.45	1.11	2.22	0.90	26.7	10.8	13.5	33.4
0.50	1.24	2.00	0.81	24.0	9.7	15.0	37.1
0.55	1.36	1.82	0.74	21.8	8.8	16.5	40.8
0.60	1.48	1.67	0.67	20.0	8.1	18.0	44.5
0.65	1.61	1.54	0.62	18.5	7.5	19.5	48.2
0.70	1.73	1.43	0.58	17.1	6.9	21.0	51.9
0.75	1.85	1.33	0.54	16.0	6.5	22.5	55.6
0.80	1.98	1.25	0.51	15.0	6.1	24.0	59.3
0.85	2.10	1.18	0.48	14.1	5.7	25.5	63.0
0.90	2.22	1.11	0.45	13.3	5.4	27.0	66.7
0.95	2.35	1.05	0.43	12.6	5.1	28.5	70.4
1.00	2.47	1.00	0.40	12.0	4.9	30.0	74.1
1.10	2.72	0.91	0.37	10.9	4.4	33.0	81.5
1.20	2.97	0.83	0.34	10.0	4.0	36.0	89.0
1.30	3.21	0.77	0.31	9.2	3.7	39.0	96.4
1.40	3.46	0.71	0.29	8.6	3.5	42.0	103.8
1.50	3.71	0.67	0.27	8.0	3.2	45.0	111.2
1.60	3.95	0.63	0.25	7.5	3.0	48.0	118.6
1.70	4.20	0.59	0.24	7.1	2.9	51.0	126.0
1.80	4.45	0.56	0.22	6.7	2.7	54.0	133.4
1.90	4.69	0.53	0.21	6.3	2.6	57.0	140.8
2.00	4.94	0.50	0.20	6.0	2.4	60.0	148.3

AUM/ha to AUM/ac	**/ 2.471**	**ha/AUM to ac/AUM**	**x 2.471**
AUM/ac to AUM/ha	**x 2.471**	**ac/AUM to ha/AUM**	**/ 2.471**
ac/AUM to AUM/ac	**1 / ac/AUM**	**ac/AUM to ha/AUyr**	**x 4.856**
ha/AUM to AUM/ha	**1 / ha/AUM**	**ha/AUM to ac/AUyr**	**x 29.652**

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